Experimental study on behaviour of RC deep beams

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Abstract - *The present work is deals with experimental study of behaviour deep beam. Objective of the present work are to study the behaviour of deep beam for shear and bending strength by experimental and analytical study using ANSYS 14.5, to compare the experimental results with analytical results. This present work deals with study on deep beams with different percentage of tension reinforcement (0.43, 0.64, and 0.86) and different grades of concrete (M25 and M30). In ANSYS 14.5 software, SOLID 65 and LINK 180 element represent concrete and reinforcing steel bars. Non-linear material properties were defined for both elements. Using ANSYS failure crack patterns, deflection at mid span and failure loads were obtained.*

The comparison between ANSYS results and experimental test results were made in terms of strength, deflection of deep beams. It was found that with increase in percentage of tension reinforcement, the flexural strength of beams increased significantly. The variation in strength, flexural steel and deflection were found to be more experimentally than the non-linear finite element analysis.

Key Words: RC deep beams, Non Linear finite element method, ANSYS 14.5, flexural capacity, crack patterns, deflection.

1. INTRODUCTION

A beam is considered as deep, if the depth of beam is in relation to the span of the beam.
According to IS-456 (2000) Clause 29, simply supported beam it acts as deep beam when the ratio of its effective span (L) to overall depth (D) is less than 2.0 and that for continuous beam when the ratio is less than 2.5. The effective span is defined as the centre to centre distance between the supports or 1.15 times the clear span whichever is less.
ACI code 318-95 classifies the beam as a deep beam for flexural if the clear span / Overall-depth ratio is less than 1.25 for simply supported beams and 2.5 for continuous beams.

In deep beams, the bending stress distribution across any transverse section deviates appreciably from the straight line distribution assumed in elementary beam theory. Consequently a transverse section which is plane before bending does not remain approximately plane after bending. Neutral axis does not lie at the mid depth. Types of deep beams may be classified as Simply Supported Deep Beams, Continuous Deep Beam & Deep Beams with and without opening. Verity of application for Deep beam is found that can be used in situations where other type of beams or structural components cannot be used such as in bridges where long spans are required. Reinforced concrete (RC) deep beams are used for load distribution in a wide range of structures; for example in tall buildings, offshore gravity structures, as transfer girders, pile caps, folded plates, and foundation walls, also shear walls are considered as cantilever deep beam. Deep beams are often located on the perimeter of framed structures where they provide stiffness against horizontal loads.

2. NON LINEAR FINITE ELEMENT ANALYSIS

The finite element analysis calibration study included modelling a concrete beam with the dimensions and properties. To create the finite element model in ANSYS 14.5 there are multiple tasks that have to be completed for the model to run properly. Models can be created using command prompt line input or the Graphical User Interface. For this model, the graphical user interface was utilized to create the model. This section describes the different tasks and entries to be used to create the finite element calibration model.

2.1 Element types

The element types used for this model is shown in below table

SL No	Material type element	ANSYS 14.5
1	Concrete	Solid65
2	Steel reinforcement	Link180
3	Support	Solid185

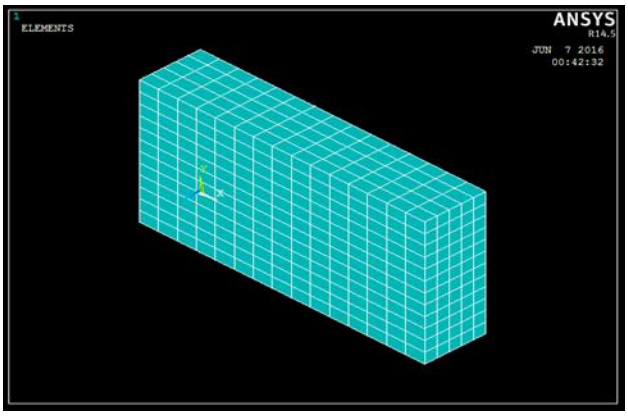
2.2 Modelling

The model was 700 mm long with a cross section of 150 mm X 350 mm.

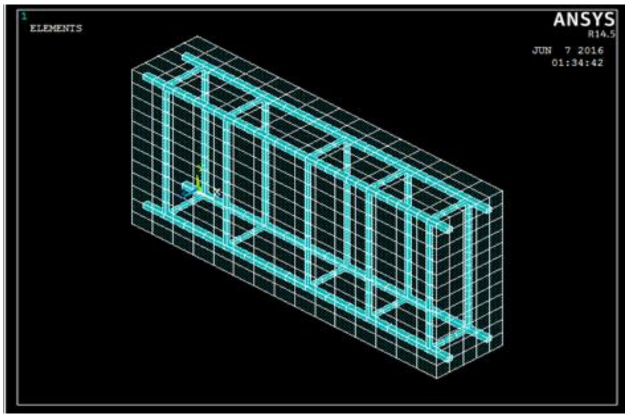
SL No	ANSYS	Co-ordinates in mm
1	X1,X2,X-coordinates	0,700
2	Y1,Y2,Y-coordinates	0,350
3	Z1,Z2,Z-coordinates	0,150

2.3 Meshing and reinforcement

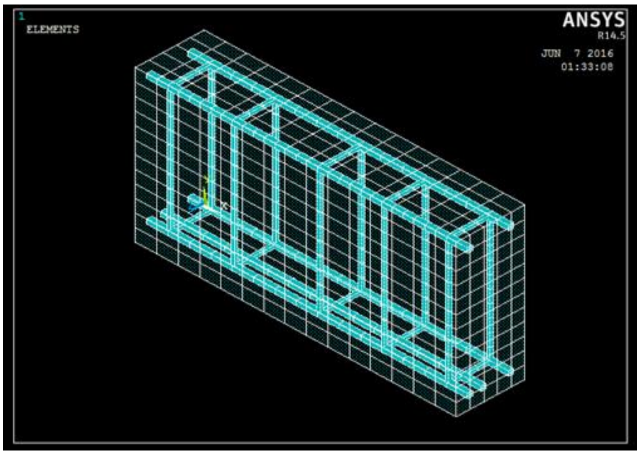
To obtain good results from the Solid65 element, the use of a rectangular mesh was recommended
No mesh of the reinforcement was needed because individual elements were created in the modelling through the nodes created by the mesh of the concrete volume.



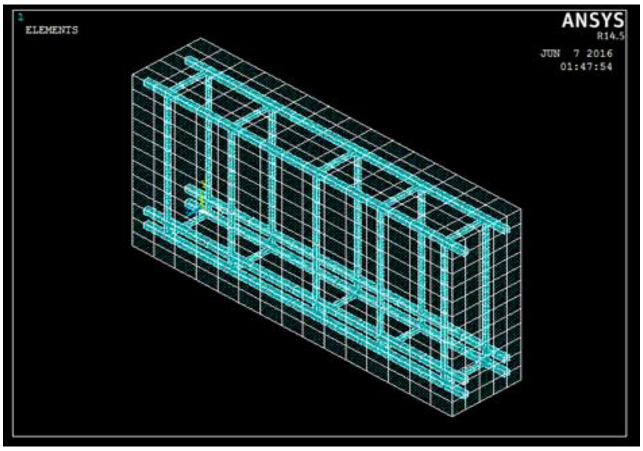
Beam model and meshing



Reinforcement details Pt 0.43%



Reinforcement details Pt 0.64%



Reinforcement details Pt 0.86%

2.4 Loading and boundary conditions

Displacement boundary conditions are needed to constraint the model to get a unique solution. To ensure that the model acts the same way as the experimental beam boundary conditions need to be applied at points of symmetry, and where the supports and loading exist. Nodes on the plate are given constraint in Y direction.

3. EXPERIMENTAL WORK

3.1 Specimen details

A total of 18 rectangular beams of size 150mm wide, 350mm deep and 700mm long were cast. Three different percentages (0.43, 0.64 and 0.86) of tension reinforcement was provided, for each variation 3 number of specimens were cast. Grade of concrete is also varied. M25 and M30. 9specimens each of M25 and M30 grade with 3 different tension steel percentages were cast. All the beams were tested over a simply supported span of 0.54 m.

3.2 Experimental programme

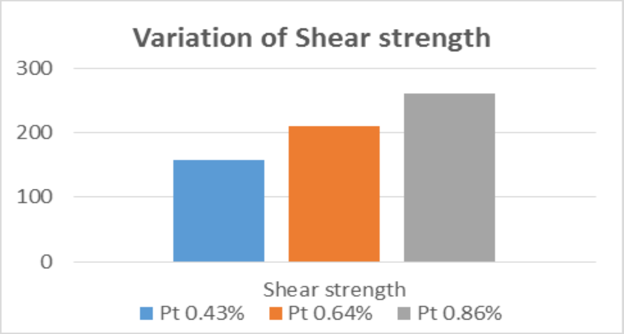
All the specimens were tested for finding out the Ultimate load carried by the Deep beams under two point loading after the age of 28 days. The beams are tested under gradually increasing load using 1000KN capacity Universal Testing Machine (UTM). All beams are simply supported with an effective span of 540mm. Beams are centred on platform and levelled horizontally and vertically by adjusting the bearing plates. Two point loads are applied at distance 1/3rd of the effective span.. Readings were taken at proper load interval. Crack propagations were traced by pencil and their tips were marked corresponding to the load readings

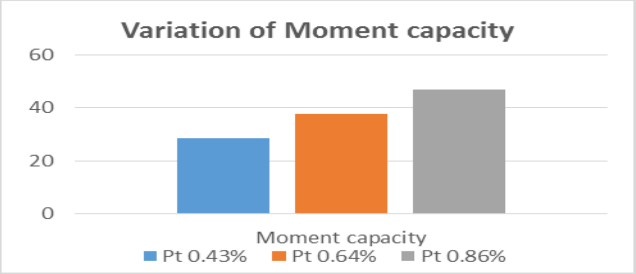
4. RESULTS AND DISCUSSION

The results obtained from the experimental investigation are tabulated in Table. From the results obtained, the effect of various parameters on shear strength of concrete are analysed and discussed as follows.

4.1 Effect of variation of tension reinforcement

The shear strength is observed to be increased with the increase in the percentage of tension reinforcement. Also it is observed that there is significant increase in moment capacity of the beam with increase in percentage of tension reinforcement.





4.2 Comparison of analytical results with experimental results

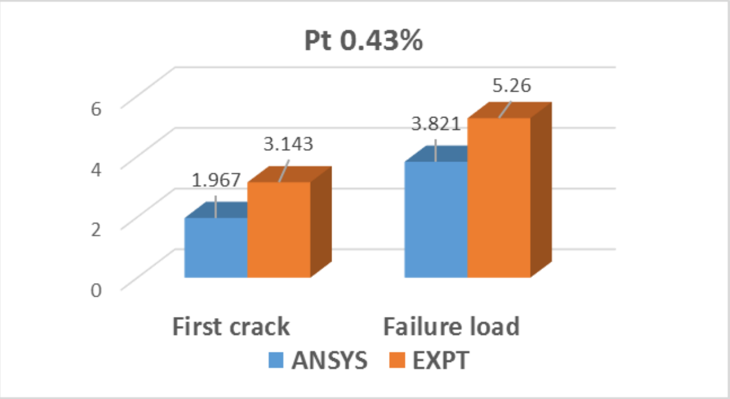
a) M25

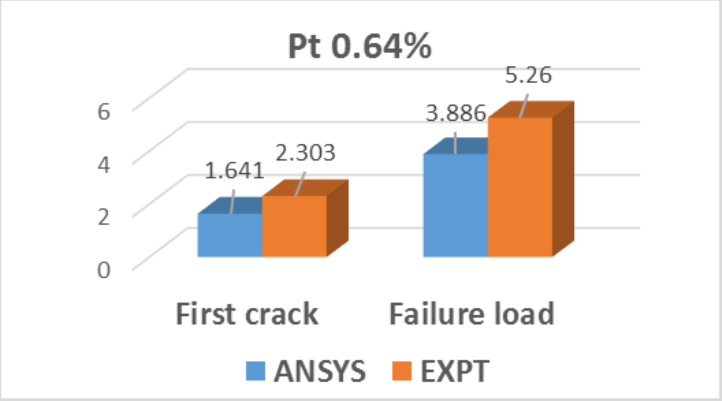
	% of tension reinforcement					
	0.43		0.64		0.86	
	FEA	EXPT	FEA	EXPT	FEA	EXPT
Load at first crack KN	138.01	157.58	181.63	204.25	203.1	222.53
Deflection at first crack (mm)	1.967	3.143	1.641	2.303	1.932	2.57
Load at failure KN	296.04	307.33	402.3	410.03	502.72	512.403
Deflection at failure load (mm)	3.821	5.26	3.886	5.023	3.632	5.54

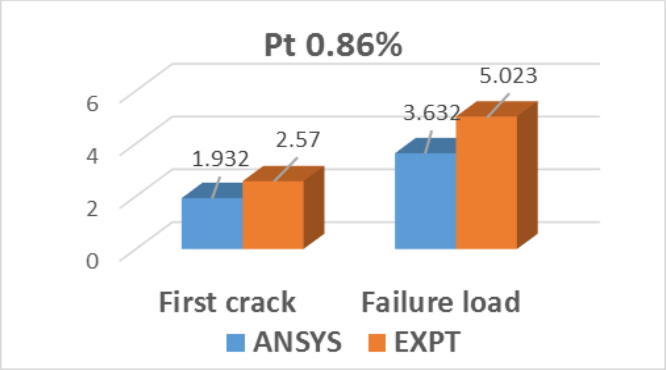
b) M30

	% of tension reinforcement					
	0.43		0.64		0.86	
	FEA	EXPT	FEA	EXPT	FEA	EXPT
Load at first crack	138.25	168.63	189.51	213.45	211.3	232.41
Deflection at first crack	1.856	2.92	1.54	2.26	1.826	2.38
Load at failure	302.44	324.63	413.83	429.29	511.34	533.16
Deflection at failure load	3.605	4.864	3.649	4.79	3.748	4.92

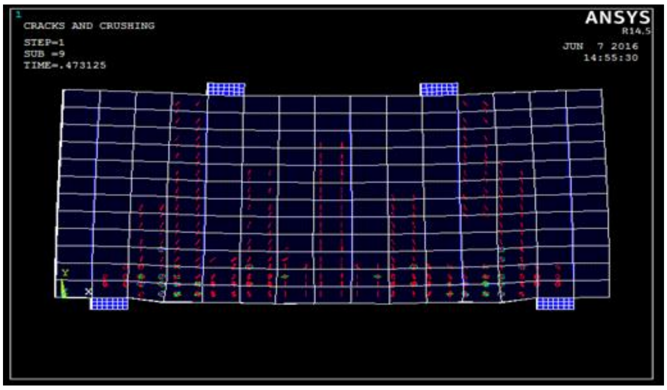
The comparison of deflections of experimental results with analytical results at first crack and failure load is shown in below graph







The crack patterns obtained in ANSYS are similar to cracks generated during experiment.



5. CONCLUSIONS

From the experimental study and from non-linear Finite Element Analysis (FEA), the following conclusions can be drawn

1) In all the beams, flexural cracks were appeared first at the central portion of the beam. Flexural cracks propagation was vertical from bottom to the 1/3rd depth of the beam.
2) Shear diagonal cracks started to appear around 42% of failure load.
3) Failure of deep beams was mainly due to diagonal cracking and it was along the lines joining the loading points and supports.
4) The shear strength and moment carrying capacity of deep beams increased significantly with increasing the percentage of tension reinforcement.
5) With increasing the characteristic strength on concrete there is slightly increase in shear strength and moment carrying capacity of deep beams.
6) The FEA results holds good with the experimental results.
7) The crack patterns obtained in FEA are similar to the cracks generated during experiment.

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